The Role of Natural Gas in the Transport Sector\textsuperscript{1}

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\textit{Natural gas is a relatively clean transport fuel, which has been promoted both by government and industry in a number of countries. But not all promotional efforts have been successful, for good economic reasons. In the light of international experience this note considers the circumstances in which natural gas may play an important role, and attempts to identify appropriate policies for establishing that role in developing countries.}

\textbf{Environmental and Economic Impacts of CNG}

CNG is a relatively clean fuel, available in abundance in many countries which do not have other indigenous fuel resources. It may thus appear attractive to governments for both environmental and economic reasons.

\textit{Environmental issues}

In comparison with a modern, catalyzed gasoline car a CNG car of equivalent size has been estimated to emit approximately 10 percent to 20 percent less CO\textsubscript{2} and particulates per vehicle kilometer, up to 25 percent less NO\textsubscript{x}, and 80 percent less CO, NMHC, and other smog forming emissions. Compared with a diesel car, the advantage is positive but considerably less for CO, NMHC and CO\textsubscript{2}, but the advantage of a CNG over a diesel car is much greater than that over a gasoline car for NO\textsubscript{x}, and can be as high as 95 percent for particulates. For buses, compared with diesel 80S Euro 2 bus, a leanburn CNG bus has an advantage in all the major pollutants, including a 20 percent advantage in global warming gases and an 85 percent advantage in particulates,\textsuperscript{2} despite the fact that the modern clean diesel bus emits only a quarter of the NO\textsubscript{x} and one eighth the particulates of the diesel bus of 1990.\textsuperscript{3} The stoichiometric CNG bus has a smaller advantage over diesel in CO and CO\textsubscript{2} (only 10 percent) than the leanburn version, but an even greater advantage in NO\textsubscript{x}.

The main environmental disadvantage of CNG is that the emissions of the greenhouse gas methane through leakage by gasoline vehicles converted to natural gas can be high. However, it is still estimated that the overall global warming impact of CNG vehicles (buses and cars) is less than that with any other liquid fuel.\textsuperscript{4} A secondary disadvantage concerns the extent to which vehicle conversion can be successful in developing countries. While this may appear to be the more economic way of achieving a rapid fleet conversion many countries have experienced such problems with poor conversions and subsequent maintenance that pollutant emission levels for all but fine particles can go up rather than down.

\textit{Economic issues}

Where natural gas is locally available but liquid fuels have to be imported (as in Argentina and New Zealand), balance of payments considerations may encourage conversion. The potential of some of the countries with a glut of natural gas (Uzbekistan, Bangladesh, Algeria) may be particularly appropriate for careful consideration.

\textsuperscript{1} This note summarizes evidence presented at a seminar on natural gas vehicles held at the World Bank in March, 2000. While there was broad agreement on the magnitude of both environmental and economic effects, the figures quoted here are averages, which should be verified in project specific circumstances, to which they may be very sensitive.


\textsuperscript{3} Gaudio, R. “Natural Gas Heavy Duty Vehicles; The OEM Perspective.” \textit{Paper presented to World Bank Seminar on Natural Gas Vehicles, op. cit.}

\textsuperscript{4} Verstegen, P. “Natural Gas Vehicles and their Impact on Global Warming.” \textit{Paper presented to World Bank Seminar on Natural Gas Vehicles, op.cit.}
If urban environmental conditions are bad enough governments may specifically mandate the use of natural gas as the transport fuel (for example, for taxis in Buenos Aires, and more recently for buses exceeding 8 years of age in New Delhi). More generally, however, the choice of fuel rests with the business or individual. The penetration of natural gas vehicles in any country thus depends primarily on its market attractiveness, which turns on a combination of the cost and convenience of the vehicle and the fuel.

As far as vehicles are concerned, there is extra cost associated with the CNG engine (or its conversion), the fuel control system and the fuel tanks. Together these increase the cost of a basic vehicle (whether a bus or a car) by up to 30 percent. That might be reduced by international unification of regulations for homologation and safety, and eventually through scale economies in OEM. In developing countries, retrofitting is the norm as the conversion of existing vehicles may be cheaper, even in the long run, than premature replacement by dedicated new vehicles. The environmental impact can be much reduced, however. Though good retrofitted kits (for example, in Argentina) work efficiently, cheap conversions may not. For example, a consequence of the conversion of a fleet of Mercedes buses in Rio is reported as having increased most emissions except those of particulates. Dual fuel vehicles are under development, but carry some extra cost penalties and are not recommended for developing countries at this stage.

As far as fuel is concerned, the pump price is comprised of the local supply price plus the storage and distribution costs plus taxes. The real resource cost (excluding taxes) depends on the local availability of fuel and density of the distribution network. For example, transportation and distribution double the well head price for a refueling station on the Atlantic coast of Colombia, but give a station cost five times the well head price for the central zone where the distribution network is only 20 percent utilized. The real economic cost is thus likely to be lowest in urban areas close to the gas fields.

The convenience factor can be very important. Vehicles lose significant amounts of luggage and passenger space to fuel tanks. Until a network of filling stations is established refueling can involve some dead running, and can be time consuming. In addition, the vehicle range may be reduced by over 50 percent, doubling the refueling frequency. All of these considerations tend to emphasize the need for a distinct financial advantage if CNG (or LPG) is to become the fuel of choice.

**INTERNATIONAL EXPERIENCES**

Those factors play out differently in different countries, from which some interesting lessons can be learned.

Argentina has the greatest penetration of gas powered vehicles, based on rich supplies of natural gas, which accounts for nearly 50 percent of the country’s primary energy. There is a network of 11,000 miles of trunk pipelines and 93,000 miles of distribution lines. Filling stations costing US$1 million pay back capital in less than three years, and there are now 774 public filling stations through the country. Initial policies to encourage CNG included strict certification to ensure fuel quality, a differential of over 65 percent between gas and liquid fuel prices, a guaranteed gross margin for filling stations, and support for the local conversion kit industry. The payback period for the conversion of a gasoline taxi running 120,000 kilometers per annum was only fifty days, and the bulk of the taxi fleet of Buenos Aires was quickly converted. But all buses and large trucks and about 50 percent of new cars, formerly including most new taxis, are now diesel powered. The problem for extension into the bus, truck and private car fleet, however, is the low price of diesel. It took an executive order of the president to force the conversion of diesel taxis to natural gas. As a consequence about 500,000 gasoline vehicles have been converted or replaced by CNG vehicles. The primary lesson from Argentina is the importance of relative fuel taxation policies.

Colombia, like Argentina, has large gas reserves in its northern region offering a possibility of substantial balance of payments savings. Pipelines built under BOT arrangements supply major cities in the region. With the CNG price fixed at 60 percent of the gasoline price, and a very inefficient fleet of gasoline buses, the CNG fleet grew to 4,500 vehicles, mainly buses. However, pipeline utilization is low and transmission costs remain high so that expansion into private vehicle fleets has been limited.

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5 For example, for the barest 12 meter low-floor bus, the extra cost of a CNG vehicle might be US$30,000 on a price of US$120,000. For the more sophisticated vehicles used in urban transport in the US and Western Europe the basic cost might be twice that, while the incremental cost of CNG would not increase proportionately.


relatively modest. The lesson from Colombia is the need for a minimum threshold of demand to keep distribution costs and prices low.

In Egypt, government policy has been driven by the desire to “clean up” Cairo, which is one of the most polluted cities in the world. It has achieved 20,000 conversions through the instrumentality of the licensing of joint enterprises of Egyptian and foreign suppliers to be involved both in the construction of filling stations and the conversion of vehicles. This linking avoids the “chicken and egg” problem of the relationship between vehicle fleet and fueling capacity. Fuel is maintained at less than half that of gasoline and the equipment suppliers link conversion to long-term fuel supply contracts so that those converters do not incur substantial initial capital costs. Very favorable terms are also available from the Social Development Fund to finance customer conversions. One lesson from Egyptian experience appears to be that there is scope for increasing the private attractiveness of gas by the development of financing mechanisms which “variabilize” the capital costs of vehicle conversions.

New Zealand experience is less encouraging. The incentive to develop natural gas as a transport fuel for New Zealand came from a combination of the effect of petroleum price rises of the early seventies on the balance of payments and the ready availability of gas supplied by a government owned oil company under a “take or pay” contract. The government instituted an R and D program in 1978, and established a CNG co-ordination agency with a target of 150,000 CNG vehicles by 1985. A national plan, including the establishment of fuel standards and the conversion of government vehicle fleets, was developed in 1979. The initial incentives to encourage conversion, including a grant of NZ$200 towards each conversion and the maintenance of a CNG price half that of petroleum, were extended, from 1981 on, to include accelerated depreciation rates on CNG vehicles, a 100 percent loan for conversion kits, and a NZ$300 fuel voucher with every conversion. By the end of 1984 the conversion rate had reached 4,000 vehicles per month and the balance of payments saving was estimated at NZ$30 million per annum. The new government, elected in 1985 with a mandate for economic deregulation abandoned these incentive systems, and the CNG fleet has fallen to 10,000 vehicles. This shows the likely unsustainability of action to “kick start” the use of CNG unless the economics are fundamentally sound.

The overall conclusion to be drawn from these case studies is that the economic viability of CNG depends on the equivalent pump price being no more than half that of the fuels with which it competes. That is the basis on which CNG vehicles have found substantial markets in Italy, Argentina and Northern Colombia. Because of the higher initial cost, and the relatively myopic view of vehicle purchasers, this can be assisted by financing arrangements to attenuate the first cost penalty (as in Egypt). Even then, the economic advantage – as well as the environmental advantage – is greatest for high mileage vehicles such as taxis and buses, and that in most countries it is likely to remain a niche fuel serving such (environmentally critical) markets.

**CRITICAL POLICY REQUIREMENTS**

From the foregoing combination of experience and reasoning it is possible to distil some conclusions about where it may be sensible to act to encourage the use of natural gas for transport, and by what instruments.

A local reserve of gas is clearly the first requirement, both because the expense of transport internationally is likely to make it uneconomic and because that increases the probability of securing a substantial balance of payments advantage by its exploitation. World reserves of gas are more widely distributed than those of liquid fuels so that developing countries like Argentina, Bangladesh and Pakistan may see a strategic advantage in its development. More important than large gas reserves is the availability of a city gas distribution network. CNG use alone is not enough to justify the development of gas field and the construction of gas transport and distribution infrastructure. Many large cities in Bangladesh, Brazil, Colombia, Indonesia, Pakistan and eastern Europe and the Former Soviet Union already have extensive gas networks.

Second is the cost relative to other fuels. IPPC estimated the wellhead gasoline equivalent production cost of CNG to lie between 70 and 90 percent that of gasoline or diesel so that, given difference in distribution and storage costs the resource costs at the pump would often be very similar. However, international evidence suggests that, except for some very heavy mileage vehicles, the pump price difference would need to be about 50 percent of the production cost of liquid fuels for natural gas to be attractive to

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8 Chapel, F. “Petroleum Industry Perspective on Worldwide NGV Development” ” Paper presented to World Bank Seminar on Natural Gas Vehicles, op.cit

9 Harris, G. “Compressed Natural Gas in New Zealand” ” Paper presented to World Bank Seminar on Natural Gas Vehicles, op.cit.

10 Equivalent in terms of power output units
users. Hence natural gas would seem to require strong fiscal encouragement if it is to be more than a niche fuel.

Arising from this are questions of fiscal policy. In many countries gasoline taxation is sufficiently high for the relative attractiveness of gasoline and natural gas to be manipulated through differential taxation. That is partly the basis of the popularity of NGVs in Italy. But it is rarely so for diesel which is for many purposes the direct competitor of CNG, and which typically carries a low tax rate. Relative tax rates may thus be encouraging the highest mileage urban vehicles (taxis, buses, etc) to switch from gasoline not to CNG but to diesel, the fuel with the most damaging urban environmental impacts.

The usual reason for low tax rates on diesel is its use for heavy inter-urban freight movement and agricultural purposes. Given that the health impact of particulate emissions is likely to be less in low density inter-urban and rural areas than in cities, the emphasis on the economic rather than the environmental impact of diesel fuelling outside urban areas may not be unreasonable. Hence it is necessary to develop tax structures which protect the urban environment but do not discourage use of the most economical fuel by agricultural or intercity freight vehicles. One possible way of doing that is to identify the most damaging vehicle types (cars and urban buses) and use high duties on those types of diesel vehicle, rather than fuel taxation, as the means of changing the balance of economic advantage. That is already done in some countries by exempting clean vehicles from import duties or vehicle license duties.

How to set relative tax levels is inevitably a complex issue. In principle, the answer is to identify the emission values of different pollutants, and to structure vehicle and fuel taxes to reflect differences in the summed value of emissions for different vehicle types. In practice, however, emission levels depend not only on the fuel type and composition, but also on where and how it is burned. Moreover, the evidence on the health costs of different pollutants remains sketchy in many countries. So, at best, the use of fiscal incentives would be somewhat rough and ready. But that may be sufficient to counteract some of the most obvious distortions in existing incentive systems.

**WHAT SHOULD THE BANK DO?**

Given these complications, what actions should the Bank be considering in its environmental and urban transport operations? The following seem appropriate:

- assist assembly and dissemination of environmental inventories and information on relative costs of different pollutants, capabilities of different fuels and technologies, and merits and drawbacks of different instruments of intervention.
- develop a tool-kit of best practices to implement CNG projects, to facilitate the design, implementation and enforcement of appropriate CNG related technical, performance and safety standards in developing countries.\(^{11}\)
- include the issues of the implications of fuel choice and fuel pricing on the environment in any World Bank policy advice notes prepared for governments.
- undertake a screening study to identify cities in the developing world capable of developing self sustainable CNG Programs.\(^{12}\)
- where there is a clear desire of government to act decisively to improve the local environment, assist in assessing the cost effectiveness of alternative fiscal and physical instruments.
- where the previous steps have formed the basis for determining a cost-effective intervention, consider financing of policy and investment measures which might include finance of some public infrastructure or vehicle conversions (possibly through IFC). In all cases, however, the element of subsidy should be carefully assessed, and limited to that which can be strongly justified through externality reduction.

**TO LEARN MORE**

The proceedings of the workshop footnoted are to be found at the following address: [http://fpsi/fpsiweb/fpsilite.nsf/64ff5a7bc419722f8525675f0075b10c/de7929e697cf10758525689b00672f8?OpenDocument](http://fpsi/fpsiweb/fpsilite.nsf/64ff5a7bc419722f8525675f0075b10c/de7929e697cf10758525689b00672f8?OpenDocument) (this is an internal link for Bank staff only).

Efforts are being made under the Latin American Clean Air Initiative to provide updated information on CNG as part of the clean air technology pool under preparation. For further details contact Anthony Bigio, WBIEN.

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11 To this end it was agreed that initially, the Clean Air Initiative in Latin American Cities and the IANGV would collaborate with the US DOE to prepare terms of reference and to identify the funding required.

12 To this end it was agreed that IANGV would work with the Bank to facilitate the evaluation of possible CNG programs in Latin America and in Asia.